

Dynamics of Local Vibrational Modes in Semiconductors I

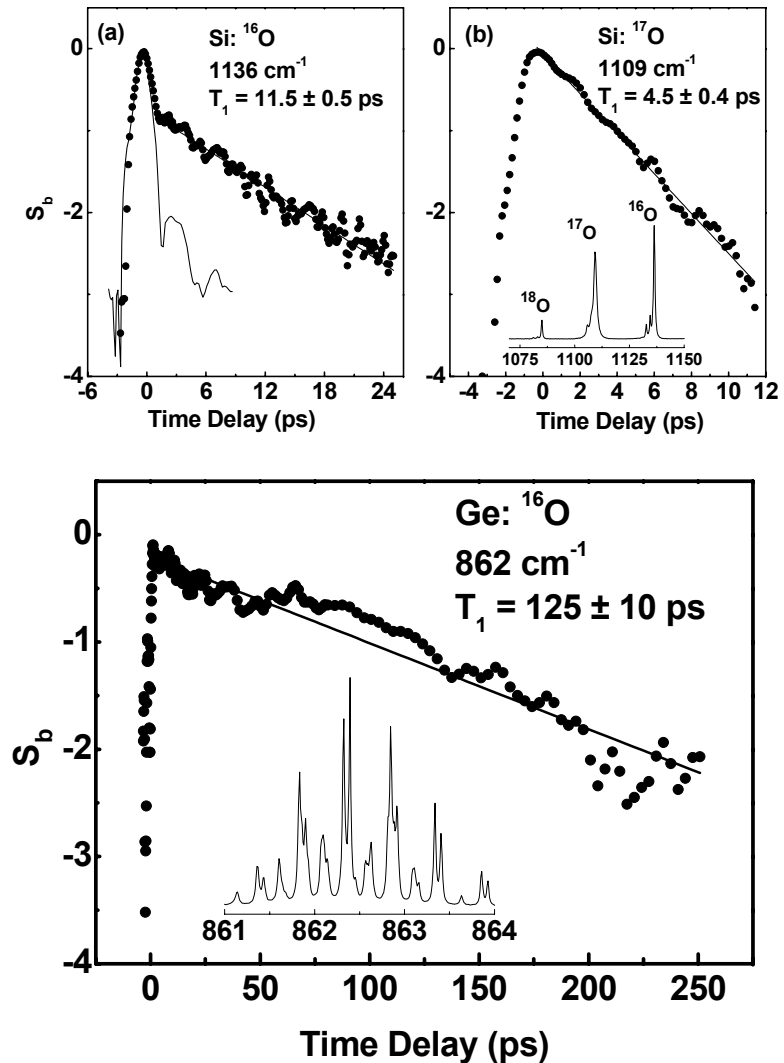
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Decay dynamics of local vibrational modes provides unique information about energy relaxation processes to solid-state phonon bath.

In this work the lifetimes of the asymmetric stretch mode of interstitial ^{16}O and ^{17}O isotopes in Si are measured at 10 K directly by time-resolved, transient bleaching spectroscopy to be 11.5 and 4.5 ps, respectively (top figure).

A calculation of the three-phonon density of states shows that the ^{17}O mode lies in the highest phonon density resulting in the shortest lifetime. The lifetime of the ^{16}O mode in Ge is measured to be 125 ps, i.e., ~ 10 times longer than in Si (bottom figure).

The interaction between the local modes and the lattice vibrations is discussed according to the activity of phonon combinations.



Omnipresent impurities such as carbon, oxygen, and hydrogen play important roles, both detrimental and beneficial, in the fabrication of solid-state devices. Oxygen is one of the most prominent impurity in Czochralski-grown silicon, which is widely being used in the semiconductor industry. The oxygen atoms are incorporated into the crystal during growth, forming interstitial Si-O-Si chemical bonds. The change of lattice structure due to oxygen incorporation causes local vibrational modes (LVMs) of the impurity complex. The aim of this experimental research program is to elucidate the microscopic dynamics of these LVMs in crystalline semiconductors. Knowledge of the rates and pathways of vibrational energy flow is critical for understanding thermally and electronically stimulated defect and impurity reactions and migration in these materials. A direct comparison between the vibrational dynamics of oxygen isotopes in silicon and germanium, which have widely different interactions with bulk vibrations in these crystalline materials, will further support the identification of the energy exchange mechanism. Our group has measured the vibrational lifetimes of the anti-symmetric stretch mode of interstitial ^{16}O and ^{18}O in silicon, and ^{16}O in germanium. The transient bleaching experiments were performed with a short-pulse tunable infrared laser. A strong pump pulse excites the local vibrational mode of interstitial oxygen and a second pulse (probe) delayed in time with respect to the pump pulse probes the change in transmission induced by the excitation of the LVM. Our experiments show large differences in the vibrational lifetimes of O isotopes, and large differences between the same isotopes of O in silicon and germanium. The results are explained by the large differences in activity and density of the accepting phonon combinations. This work is published in Phys. Rev. Lett. 92, 2004, pp. 185503-06.

Dynamics of Local Vibrational Modes in Semiconductors II

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Educational

1 undergraduate,
1 grad students,

A laser and optics course for graduate and undergraduate students was taught. This course provides a basis for understanding and use of lasers and modern optics in medicine, science, and technology.

Several guest lectures were given, for example on free-electron laser science, pulsed laser-deposition, application of synchrotron radiation, etc.

Organization

The International Symposium On Hydrogen In Matter (ISOHIM) Board was founded as a nonprofit organization registered in the Commonwealth of Virginia.

Mission

The mission of the ISOHIM Board is to promote the development of the basic understanding of the hydrogen-matter interactions on an international level. The Board will strive to achieve its mission by holding international symposia, by promoting the interchange of information and by collaborations.